



# Global value chains, financial constraints, and innovation

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**Abstract** This paper analyzes the effect of firms engaging in global value chains (GVCs) and suffering from financial constraints on innovation. To explore this relationship, this study relies on firm-level data from World Bank Enterprise Surveys (WBES) for 146 countries during the period between 2006 and 2020. The aim of this paper is to empirically link two literature strands, the one of GVC participation and that of financial constraints, and to examine their individual effects, in addition to the effect of their interaction on innovation. Extended probit model is used to account for the endogeneity problem that may arise when studying the effect of GVC participation and financial constraints on innovation, by using a set of instrumental variables. This paper controls for heterogeneity among firms (by country, region, and industry), firms' characteristics, reverse causality, and sample selection. The results of this paper show that financial constraints impede firms' probability of innovation even if the firm is participating in GVC. This means that the negative effects of financial

constraints outweigh the positive effects of GVC participation on innovation.

**Plain English Summary** The main findings show that firms that are jointly financially constrained and participants in GVCs have lower probability of innovation. This implies that the negative effects of financial constraints outweigh the positive effects of GVCs on innovation. This study has important policy implications. Governments should use several policies to encourage firms' participation in GVCs and to ensure they have better financial structure. Therefore, policymakers may facilitate lending and financing procedures by providing financial assistance or offering loans with easier terms. However, this strategy should not neglect a careful screening and monitoring process. Moreover, governments may provide tax incentives, such as R&D tax allowance or R&D tax credit incentives, to nascent participants in GVCs to encourage them to innovate. They may also incentivize firms to increase their investments in innovation by lowering tax rates on firms with worldwide recognized innovations. Finally, governments may as well provide non-financial assistance to firms in form of trainings and assistance programs.

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## 1 Introduction

Innovation is the main driver of growth, and it is crucial for a sustainable economic development (De Marchi et al., 2015). It is defined as the implementation of a new or improved product (good or service) or process in the market (Mortensen & Bloch, 2005). Innovation does not only improve the economy at the macro level, but it is also beneficial at the micro level since it improves firms' productivity growth and increases their competitiveness in the market (Aghion et al., 2012). It is worth noting that innovation is improved due to several factors such as global value chain (GVC) integration. Conversely, it is impeded by numerous elements such as firms' financial constraints.

Global value chains have become a dominant feature of world trade (OECD, 2013). GVC is defined as the different stages of production dispersed across different countries to produce a good or a service, where each stage adds a value to the final product. A firm is considered as a participant in a GVC if it participates in at least one stage of production (Antras, 2019). Subsequently, firms tend to integrate in GVCs because in GVCs, trade and investments are better organized and there is an international fragmentation of production (Dovis & Zaki, 2020). This fragmentation allows firms to enter global markets as components or service suppliers, without having to build a product's entire value chain (OECD, 2013).

Nevertheless, innovative activities are costly and difficult to finance. As a result, innovative firms face several challenges in financing their investments, specifically if they initially suffer from financial constraints. In consequence, firms that face financial difficulties tend to reduce their investments in innovative activities and research and development (R&D) projects. These financial constraints are more likely to exist in developing countries due to the presence of underdeveloped financial markets and institutions, which result in reducing their firms' innovative investments and hindering the country's economic growth (Chundakkadan & Sasidharan, 2019). Correspondingly, there is a consensus in the literature that well-functioning financial markets increase countries' economic growth by stimulating technological innovation (Brown et al., 2009; Kerr & Nanda, 2015).

A strand of the literature focuses on the improvement in firms' innovative investment resulting from

their integration in GVCs (Gereffi, 1999; Giuliani et al., 2005; Humphrey & Schmitz, 2002). These studies find that GVC participation allows for diffusion of information technology between firms due to the internationalization that leads to evolving inter-firms' associations (Brancati et al., 2017). Therefore, firms participating in GVCs benefit from knowledge transfers from lead firms, which allow them to compete in the international market, increase their competitiveness, reduce their production costs, and consequently improve their innovative capabilities (Gereffi et al., 2005).

Moreover, firms can also profit from indirect technological transfer and upgrade in developing countries. The indirect technological transfer may take several forms: first, the transfer may take the form of foreign direct investment (FDI) by a firm having access to competitive technologies and transferring them to developing countries. Second, access to technology may be gained through a foreign firm which licenses its technology to a domestic firm, meaning that the foreign firm receives money in exchange for allowing the downward firm to use the technology. Thirdly, technology can be transferred through importing capital goods such as machinery and equipment which embody innovative technology. Fourthly, it may take the form of imported intermediate goods, which facilitates the production of new and advanced products improving firm's productivity. Lastly, technological upgrading may be promoted through consumer demand effects, which will result in producing goods that appeal to a wide range of consumers and adhere to the internationally harmonized product standards (UNESCAP, 2015).

Another strand of the literature tackles the negative effect of financial constraints on innovation. Empirically, most papers find that firms suffering from high levels of financial constraints are less likely to innovate and to invest in R&D projects (Aghion et al., 2012; Ayalew & Xianzhi, 2019; Chundakkadan & Sasidharan, 2019; Savignac, 2008). It is worth mentioning that most of the empirical studies have limitations in solving the endogeneity problem that may arise from estimating this relationship (Ayalew & Xianzhi, 2019). For this reason, this paper deals with the endogeneity problem. Contrarily, limited literature finds a positive effect of financial constraints on innovation. In this case, financial constraints are acting as a stimulus to innovation and creativity; thus,

firms are driven to use less costly resources, fewer inputs, and lower budget (Fernandez, 2017; Hewitt-Dundas, 2006; Scopelliti et al., 2014).

The aim of this paper is to estimate the effect of financial constraints, GVC participation, and their interaction on the probability of innovation. Since most of the literature focuses on the positive individual effect of GVC participation on innovation, this paper tends to explore the obstacles facing firms participating in a GVC, and then examine whether these obstacles are strong enough to limit these firms' innovative activities. Access to finance is considered as a major obstacle facing firms participating in GVCs<sup>1</sup> (Reddy, 2020). Therefore, this paper focus on the interaction between GVC participation and one of the major obstacles facing firms engaging in GVCs, namely financial constraints, and examine their effects on innovation. By using World Bank Enterprise Surveys (WBES) during the period between 2006 and 2020, this paper studies if the participation of a firm in GVCs would mitigate the negative effects of financial constraints on the probability to innovate.

This study contributes to the existing pool of literature in several ways. First, it provides a bridge between two strands of literatures: one of which is on the effect of GVC participation on innovation and the other is on the effect of financial constraints on innovation. It empirically tackles the individual effect of financial constraints and GVC in addition to the interaction between both variables on innovation. Second, this paper uses extended probit model. This technique is beneficial because it solves the endogeneity problem of GVC participation and financial constraints by allowing the use of instruments, unlike the classical probit model. Moreover, it allows for the use of more than one binary endogenous independent variable: GVC participation and financial constraints, unlike the instrumental variable probit model. Furthermore, it allows the interaction between the endogenous variables. Third, this paper uses different definitions of GVC, financial constraints, and innovation. It uses four definitions of GVC integration—whether the firm is a two-way trader only, or if it also has a quality

certification, or if it has a foreign ownership, or if it benefits from all of them. It also compares financial constraints from two aspects: perception-based and factual-based to capture the actual effect in the market, in addition to the effect from the firm's point of view. As for innovation, it is captured by whether the firm introduced a new product or service in the market and by whether the firm spends money on R&D projects during the last fiscal year.

The remainder of this paper is structured as follows: Section 2 highlights the theoretical and empirical studies on the effect of GVC participation on innovation, in addition to the effect of financial constraints on innovation. Section 3 presents the data and the descriptive statistics on the relationship between integration in GVC, financial constraints, and innovation. Section 4 provides the methodology used to estimate this relationship. Section 5 is devoted to analyzing the empirical findings of the paper and the model extensions. Section 6 focuses on robustness checks and Section 7 presents the conclusion.

## 2 Literature review

This part shows the theoretical and empirical literature studying first the effect of GVC participation on innovation, followed by the effect of financial constraints on innovation.

### 2.1 GVC participation and firms' innovation

Recent decades have witnessed major changes in international trade. GVC trade in the twenty-first century, which is different from traditional trade, is characterized by the following two features: hyper-specialization and durable firm-to-firm relationships. In GVCs, industries are characterized by a large number of small suppliers who interact frequently (World Bank, 2019). This segmentation improves the economy both at the micro level and the macro level: at the micro level, it leads to an increase in firms' income and an improvement in their productivity. At the macro level, it leads to more development, growth, poverty reduction, and more integrated economies worldwide (Gereffi, 2014).

Moreover, GVCs result in higher levels of innovation and technological upgrading. GVC participation may lead to economic upgrading by moving from

<sup>1</sup> Figure 12 in the Appendix presents the percentage of obstacles faced by firms participating in GVCs on average between 2006 and 2020. It shows that most firms participating in GVCs face major obstacles in tax rates, access to finance, and inadequately educated workforce.

low to high value-added activities (Gereffi, 2005, 2014, 2019). This has the benefit of pushing firms to innovate more through developing new products and processes or improving the existing ones in order to increase efficiency and move towards higher value-added activities (Humphrey & Schmitz, 2002).

Despite the availability of theoretical studies explaining the mechanisms of GVCs, the empirical studies on this topic are limited. Empirically, Dang and Dang (2020) focus on the case of small and medium enterprises (SMEs) in Vietnam between 2007 and 2015. They study whether higher share of foreign value added of Vietnamese firms incites them to innovate more. They find that foreign value added in gross exports increases the probability of SMEs to improve existing products but decreases the probability to introduce new products in the market. Moreover, Tajoli and Felice (2018) calculate the effect of GVC participation on innovation performance in developed and developing countries using World Input Output Database (WIOD). They find that GVC participation increases innovation levels, especially for developing countries that rely on inputs from developed countries. Thus, they conclude that international fragmentation of production and GVCs are channels of high innovation, international technology, and knowledge transfer from developed countries to developing ones.

An important strand of the empirical literature perceives modes of governance as central in their analysis since they determine the power of the relationships existing within the chain. Thus, they perceive that some coordination forms may increase the level of technology and knowledge diffusion more than others (Brancati et al., 2017; De Marchi et al., 2015; Giuliani et al., 2005; Pietrobelli & Rabellotti, 2011).

In this framework, Giuliani et al. (2005) focus on Latin American countries and find that a firm's level of upgrading does depend not only on its efforts, but also on the environment where it operates. They distinguish three types of governance—network, quasi-hierarchy, and hierarchy. Network is a form of horizontal cooperation, and hierarchy is a form of vertical cooperation. They conclude that the different forms of governance are important determinants of a firm's upgrading level, and that the results have different implications on whether the upgrading is functional, or whether it is in the innovation of new process or product.

Similarly, Brancati et al. (2017) study the diffusion of GVCs in the Italian system between 2008 and 2013. To test this relationship, they rely mainly on random effects model, but they also use several empirical strategies such as fixed-effect estimator, two-step system GMM, and matching technique to alleviate the reverse causality problem. They find that firms involved in GVCs have more propensity to innovate, grow, and undertake R&D projects than other firms participating in national value chains or stand-alone firms. The authors extend their analysis in 2017 to analyze how the great recession affects the behavior of Italian GVCs. They find that modes of governance of GVCs explain the heterogeneity in innovation level.

Thus, there is a consensus in the literature that GVCs increase firms' innovation levels, especially for developing countries, and that the level of technology and knowledge transfer depend on the mode of governance.

Besides, it is worth mentioning that firms participating in GVCs do not only have higher levels of innovation, but they have also better financial structure to enable them to enter the international market. Due to the large sunk costs incurred to enter exports market, only less constrained firms may have the ability to enter it (Bernard & Jensen, 2004). However, financially constrained firms are less likely to participate in GVCs (Reddy, 2020).

## 2.2 Financial constraints and firms' innovation

According to endogenous growth models, innovation is the main driver of economic growth. Nevertheless, investing in new technology may be challenging, especially in underdeveloped capital markets, because it is very costly, and it induces firms to resort to external sources of finance. These sources of finance are not offered easily for several reasons. First, investing in innovation does not only require high level of investments, but it also leads to uncertain outcomes and high risks. Usually, neither the firm nor the investor knows the real value of the investment and whether it will yield high returns or not (Holmstrom, 1989). Second, moral hazard problems may occur (Arrow, 1962), as firms may change ex-post behavior resulting in increasing the risk on lenders. Third, information asymmetry problems between firms and investors may arise. When an

innovative firm gets an external source of finance to fund a new technology, the success of this technology is held asymmetrically between the firm and investors, making it difficult for the latter to evaluate the quality of this new technology (Arrow, 1962).

Most of the empirical literature finds that financial constraints negatively affect firms' innovation levels (Aghion et al., 2012; Chundakkadan & Sasidharan, 2019; Gorodnichenko & Schnitzer, 2013; Savignac, 2008). However, some studies find a positive effect (Fernandez, 2017; Lööf & Heshmati, 2006; Mohnen & Röller, 2005).

On one hand, an important strand of the literature highlights the intensity of financial constraints in developing countries, focusing on firms' age, size, sector, and source of finance as important determinants of accessing finance. In this regard, Ayyagari et al. (2011) study the effect of financial constraints on firms' innovation in emerging markets. In their analysis, they rely on data from WBES for 47 developing countries during the period between 2002 and 2004. Using a logit model, they find that firms that innovate the most are those with less credit constraints because they have access to external sources of finance such as bank financing, and they have part of their borrowing in a foreign currency.

Similarly, Chundakkadan and Sasidharan (2019) study 100 countries from WBES between 2006 and 2017. Using instrumental variable probit and special regressor model, they find that financial constraints impede firms' innovation level. They find also that the negative effect holds when dividing the sample into different regions, different income categories and different industry classifications.

Likewise, Ayalew and Xianzhi (2019) focus on 11 African countries with underdeveloped financial markets, and small banking systems. In their paper, they investigate the effect of financial constraints on innovation using WBES and Innovation Follow-Up Survey. Using recursive bivariate probit model, they find that financial constraints reduce innovation and reduce the probability of having product and process innovation. They also find that this negative effect prevails more in the manufacturing sector than in the service sector, in younger firms than older ones, and in micro and small enterprises than medium and large firms. Additionally, this effect decreases with the firm size.

On the other hand, another strand of the literature focuses on the effect of credit restrictions on firms' innovation in developed countries, along with accounting for firms' age, size, sector, and source of finance as important determinants of their ability to get financing. In this context, Brown et al. (2009) aim to quantify the degree of financial constraints faced by innovative firms in the USA. They prove that in high-tech sectors, young and publicly traded firms rely mainly on their internal sources of finance since external debt is not easily accessible because of the lack of collateral, uncertain returns, and information problems. This phenomenon is also more severe in the case of small firms because of difficulties in accessing information concerning their innovative capabilities and their creditworthiness. Consequently, these firms are more financially constrained in their R&D investments compared to large firms.

Testing this effect in France, Savignac (2008) uses a survey addressed to the French established firms. By using a recursive bivariate probit model, he finds that financial constraints reduce the firm's probability of innovation, and that innovation increases with the size of the firm. Likewise, Aghion et al. (2012) use a French firm-level panel dataset between 1993 and 2004. They find, using the generalized method of moments (GMM) approach, that firms' investment in R&D is lower in more constrained firms. This result prevails for firms relying on external sources of finance.

Additionally, Gorodnichenko and Schnitzer (2013) use data from World Bank Business Environment and Enterprise Performance Surveys (BEEPS) from 2002 to 2005 for 27 transition countries. They find that firms facing severe financial constraints—either in the form of a liquidity shock or a high cost of accessing external finance—are less likely to innovate or export, especially for small and young firms in the service sector.

Limited literature finds a positive relationship between financial constraints and innovation. In this regard, Fernandez (2017) finds that firms that are financially constrained can have a counter-intuitive positive level of innovative investments. To prove this relationship, she conducts her analysis using WBES for Latin American countries in 2006 and 2010. Using a logit model, she concludes that financial constraints are considered as a main driver of innovation in Latin American countries, along with the firm size,

age, and source of finance. She highlights that there is a positive association between innovation and the size and age of the firm; the larger and older the firm, the more likely is to conduct innovative activities.

Furthermore, Hewitt-Dundas (2006) finds that financial constraints improve innovative activities since firms may suffer from financial constraints due to an early investment in product development and R&D. Thus, firms will try to overcome this problem by innovating and implementing business strategies.

This counter-intuitive positive relationship is also observed in case of using direct indicators of financial constraints as in Mohnen and Röller (2005) or in Lööf and Heshmati (2006), who used Community Innovation Survey (CIS) for European countries. This positive effect is also obtained in some studies when not accounting for the endogeneity problem. Notably, the effect becomes negative once accounting for endogeneity problem (Chundakkadan & Sasidharan, 2019; Savignac, 2008).

Given the literature on GVC and financial constraints, this paper provides a bridge between the two strands of the literature. The literature shows that GVC positively affects innovation, and financial constraints tend to reduce innovation. Thus, this paper empirically examines the individual effect of these variables, in addition to the effect of the interaction between GVC participation and financial constraints on innovation.

### 3 Data and stylized facts

This part presents the data used in this analysis, as well as the descriptive statistics on firms participating in GVCs, the financial constraints they face and their innovation level.

#### 3.1 Data

Firm-level data is obtained from World Bank Enterprise Surveys (WBES) database which offers an extensive array of economic data from 146 developing countries during the period between 2006 and 2020.<sup>2</sup> WBES database covers a wide range of

business environment topics including firms' general information, infrastructure, trade, access to finance, regulation and taxes, business licensing, competition, corruption, crime and informality, innovation and technology, performance measures, and perceptions about obstacles to doing business (WBES, 2021). This data is used to construct the main variables of interest in this model which are GVC participation, financial constraints, and innovation.<sup>3</sup>

As for GVC participation, this paper follows DAVIS and Zaki (2020) by constructing several measures of different degrees of GVC. They suggest four definitions of GVC according to four dimensions: (1) export status, (2) import status, (3) international quality certification, and (4) foreign ownership. First, the least strict definition contains firms that export and import simultaneously (two-way trader). The second and third definitions are stricter and can be seen as substitutes; they cover firms that are two-way traders and have either international quality certification or a share of their capital is owned by a foreign firm. The fourth definition is the strictest one encompassing all four dimensions, namely exporting, importing, having a quality certification, and a foreign ownership (Davis & Zaki, 2020).

Thus, four dummy variables measuring the degree of participation in the GVC are shown in this model, taking the value of 1 if the corresponding definition is respected, and 0 otherwise. Several regressions are run for each of these definitions, but the preferred form is the strictest one because it shows the maximum level of participation in a GVC.

As for financial constraint indicators, this paper compares between two measurement methods—the factual-based method and the perception-based method. The factual-based method is based on the methodology adopted by Kuntchev et al. (2013) who construct four major groups to measure the degree by which firms are credit constrained during the fiscal year mentioned in each survey.

The first group is labelled not credit constrained (NCC), and it encompasses firms that rely on either external or internal sources of finance and that did not apply for a loan during the previous fiscal year as they have enough capital and do not need one.

<sup>2</sup> Table 7 in the Appendix provides a description of the countries, years, and number of firms in the sample.

<sup>3</sup> Table 8 in the Appendix provides the definitions of the variables used.

The second group is labeled maybe credit constrained (MCC), and it includes firms relying on external sources of finance for working capital and/or investment and/or have an outstanding bank loan during the time of survey, and that applied for a loan during the last fiscal year.

The third group is labelled partially credit constrained (PCC), and it contains firms using external sources of finance for working capital and/or investment and/or have an outstanding bank loan during the time of survey, and that did not apply for a loan during the previous fiscal year for reasons other than having enough capital, or it may have applied for a loan, but it was rejected.

The last group is labelled fully credit constrained (FCC), and it covers firms that did not use external sources of finance for both working capital and investments during the previous fiscal year, and that did not apply for a loan during the time of the survey, or applied for a loan but it was rejected, and that do not have an outstanding loan at the time of the survey.<sup>4</sup>

Hence, following Kuntchev et al. (2013) and Gómez-Ramírez (2019), the categorical financial constraint variable is transformed into a binary variable taking the value of 1 if the firm wanted to get external financing, but could not for some reason. The value 1 corresponds to the two categories of PCC and FCC in Kuntchev et al. (2013) methodology. The binary variable takes the value of 0 if the firm did not obtain external sources of finance, or it did not want to get any. The value 0 in this case corresponds to the two categories of MCC and NCC in Kuntchev et al. (2013) methodology.<sup>5</sup>

The perception-based financial constraint indicator is a dummy variable having the value of 1 if the firm perceives access to finance as its biggest obstacle, and 0 otherwise.

To measure the degree of firms' innovation, this paper follows the approach used by Reddy et al. (2021). Innovation is measured by the ability of the firm to introduce new products in the market. Thus, a dummy variable is used taking the value of 0 for

**Table 1** Firms participating in a GVC—different definitions

GVC	Observations	Percentage of total number of firms
Two-way	23,377	14.65%
Two-way and international certification	10,788	6.54%
Two-way and foreign ownership	5,854	3.51%
All	3,273	1.95%

Source: calculated by the authors using data from WBES

firms with no innovation and 1 for firms which have introduced a new product or a new service in the market in the last three years.

### 3.2 Stylized facts

This part aims to describe the different definitions of GVC, firms' financial constraint level, innovation level, as well as the relationship between them. It analyzes the determinants of these variables such as the country income level and firm size. It should be noted that firm size is determined based on the number of employees working in the firm, where small firms are those hiring less than twenty employees, medium ones have a number of employees between 20 and 99, and large firms are hiring more than 100 employees.

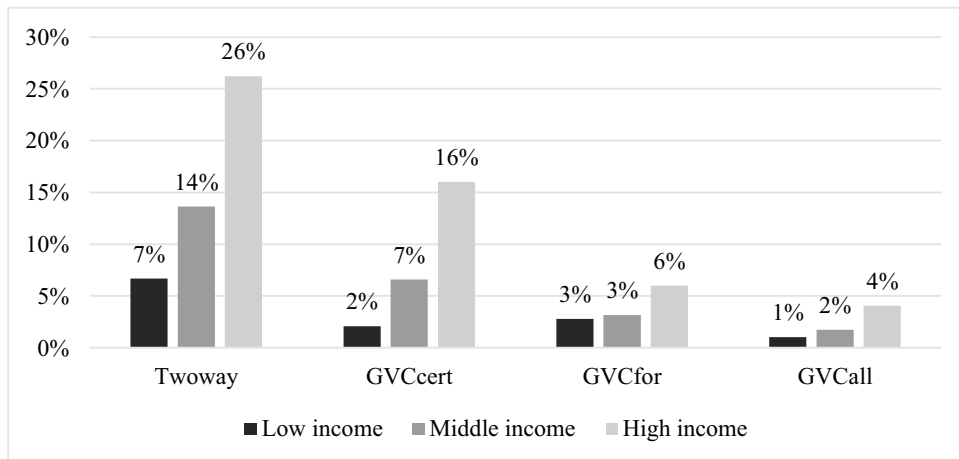
#### 3.2.1 Firms' participation in GVC

Table 1 shows the percentage of firms according to the different definitions of GVCs. Around 15% of firms in the sample export and import simultaneously which represents the highest percentage of GVC integration. Seven percent of firms are two-way traders with an international certification, 4% are two-way traders with foreign ownership, and 2% of firms' export and import, simultaneously, have international certification, and have foreign ownership. Thus, the share of firms integrating in GVC decreases as the definition becomes stricter.

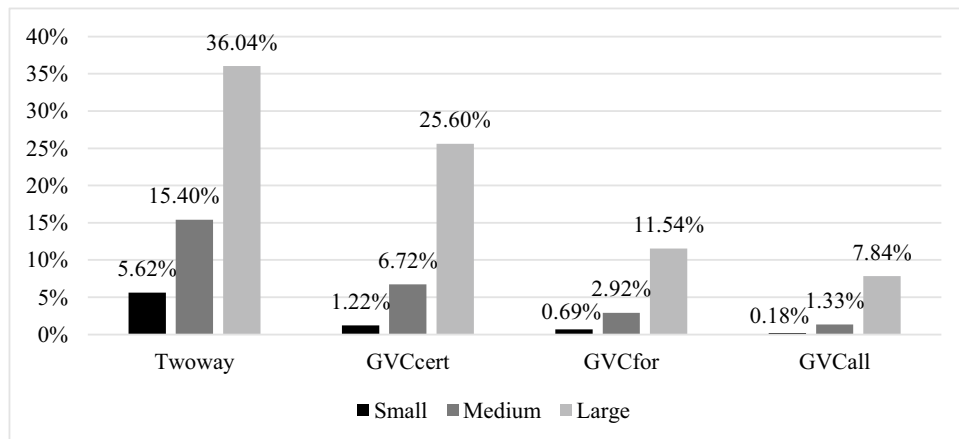
Extending the analysis by region, Fig. 1 shows that GVC integration is concentrated in high-income countries, followed by middle-income countries. These high-income countries have developed their production systems, acquired new technologies, and started to have strong regional integration of the

<sup>4</sup> Table 9 in the Appendix provides the survey questions used to construct the variables.

<sup>5</sup> A chart explaining the financial constraints factual-based indicator is presented in Fig. 13 of the Appendix.



**Fig. 1** Average share of firms participating in GVC by income level. Source: calculated by the authors using data from WBES



**Fig. 2** Average share of GVC participation by firm size. Source: calculated by the authors using data from WBES

production structure (Jones et al., 2019). Thus, their firms become more efficient and highly productive, and their production process becomes the most fragmented across countries (World Bank, 2019).

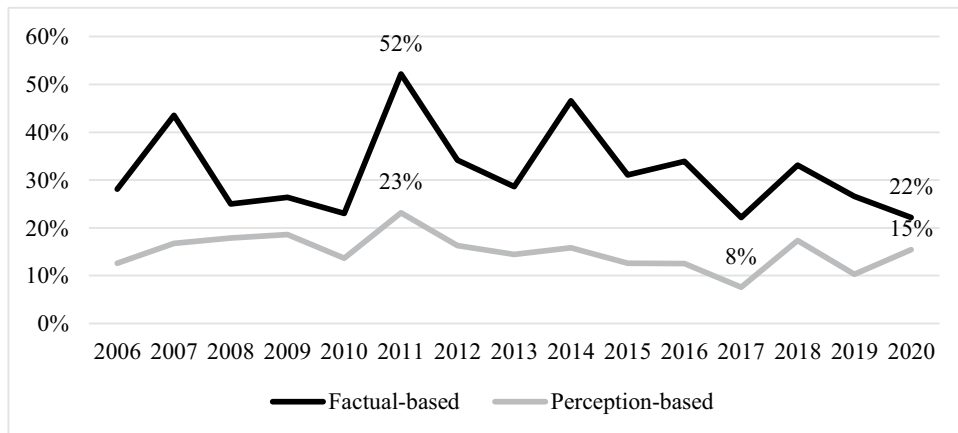
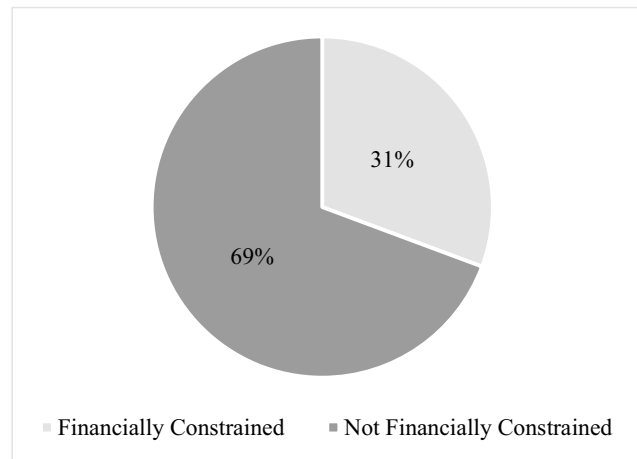
Similarly, middle-income countries have experienced an increase in their GVC participation because it allows developing countries to generate productivity gains in the international market. Also, it allows them to escape the middle-income trap, which is defined as a slow-down in trade activity that can be overset by moving to higher value-added activities in the same industry or in different industries (Engel & Taglioni, 2017). However, for low-income countries, as these regions are underdeveloped, they have

a smaller number of exporters and have weak regulatory institutions and inadequate transportation network, which can reduce their competitiveness (World Bank, 2019).

Participating in a GVC is not accessible to all firms because it requires high productivity and high transaction costs to comply with the global market standards. It is obvious from Fig. 2 that large firms are more incentivized to participate in GVCs because they are more productive and they include offshoring and outsourcing as important goals in their trading strategy. Large firms have higher ability to afford the fixed costs of exporting and importing compared to small- and medium-sized



**Fig. 3** Average share of firms that are financially constrained. Source: calculated by the authors using data from WBES



**Fig. 4** Share of firms that are financially constrained from 2006 to 2020. Source: calculated by the authors using data from WBES

firms. Moreover, small firms face several obstacles that prevent them from participating in GVCs since they cannot react quickly to changes in market structure.

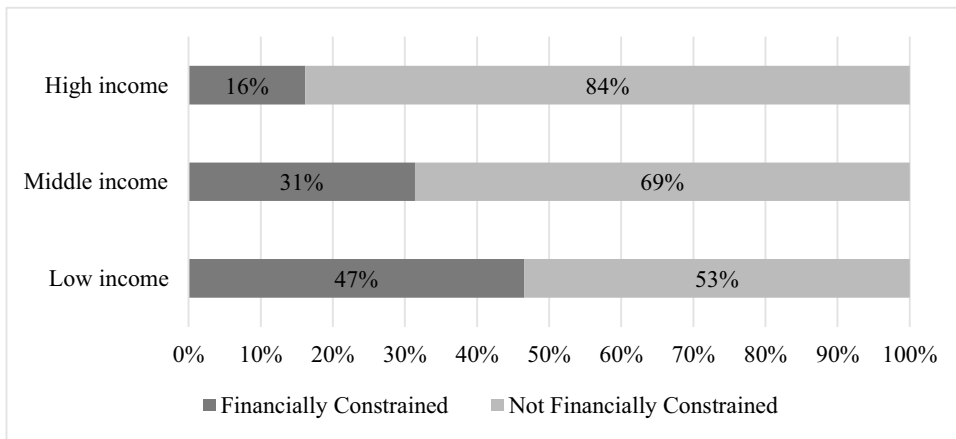
### 3.2.2 Firms' financial constraints' level

Financial constraints occur when firms face difficulties in obtaining funds from the credit market, which impedes their investment level. An important number of firms suffer from financial constraints and barriers limiting their access to the credit market. As illustrated in Fig. 3, around one-third of the sample of firms in developing countries is facing financial constraints. It is worth mentioning that high levels of financial constraints negatively affect

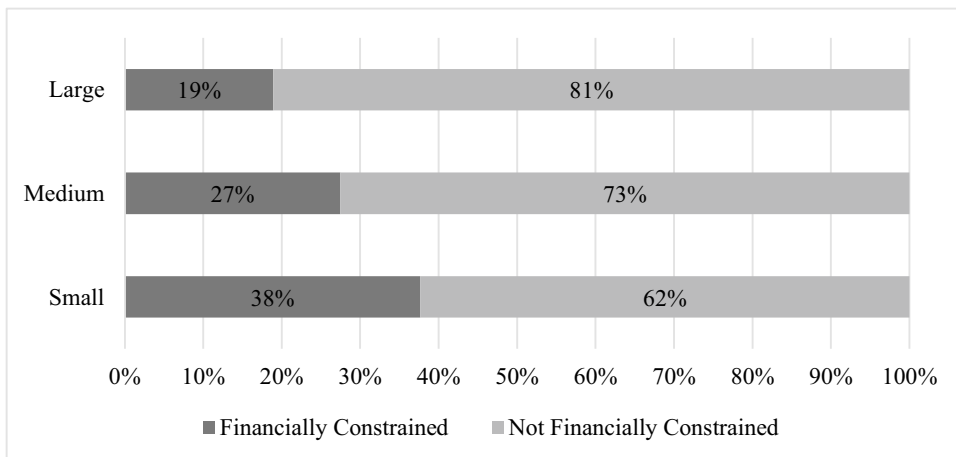
firms' investments, especially innovative investments (Chundakkadan & Sasidharan, 2019).

Differentiating between the two definitions of financial constraints—the factual-based and the perception-based definition, Fig. 4 shows that firms perceive themselves as having better financial status than the factual representation. This is reflected by the fact that firms' actual financial constraints figures vary from 22 to 52%. However, from firms' points of view, they are at most constrained by 23%. Thus, the two definitions exhibit similar trends throughout the years but with a significant gap. In 2020, the gap started to shrink considerably.

Throughout the years, the percentage of firms facing financial constraints keeps fluctuating, reaching its lowest value in 2020, which is a good



**Fig. 5** Average share of firms that are financially constrained by income level. Source: calculated by the authors using data from WBES



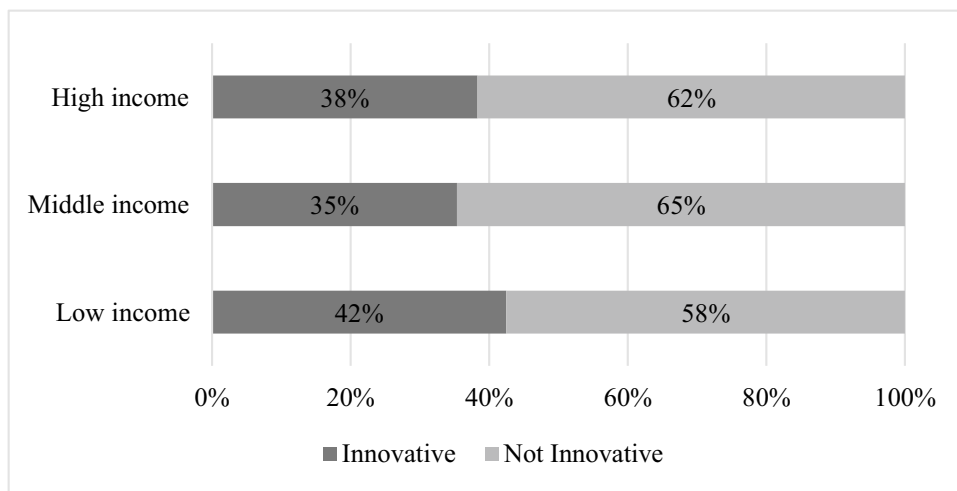
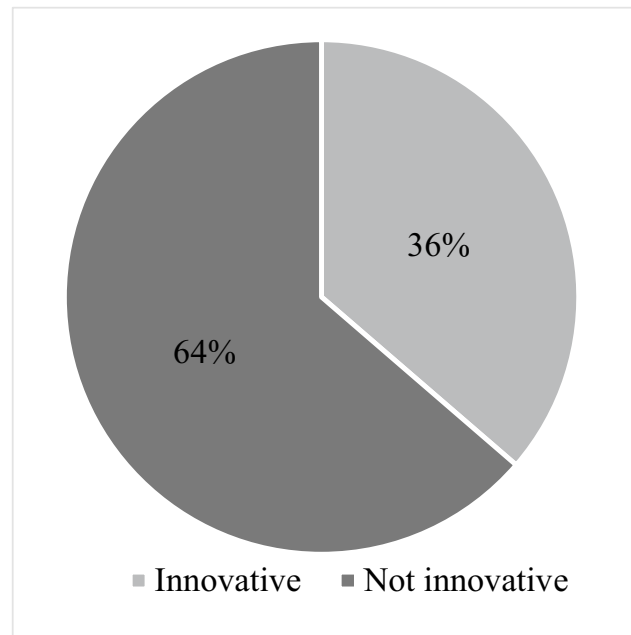
**Fig. 6** Average share of firms that are financially constrained by firm size. Source: calculated by the authors using data from WBES

indicator showing that firms have higher abilities to access external sources of finance. This allows firms to realize their growth ambitions that are related to innovative investments.

Figure 5 confirms that developing countries with low-income levels face higher financial constraints compared to developing countries with high-income levels. This figure shows that the degree of financial constraints increases with lower-income level due to the underdeveloped financial sectors existing in developing and transition economies (Gorodnichenko & Schnitzer, 2013).

Moreover, firm size is an important determinant of whether the firm is financially constrained or not. Figure 6 confirms that financial constraints are more severe in small firms, followed by medium firms, then large ones. Thus, financial constraints become higher as the firm size is smaller. This can be attributed to the fact that small firms have not yet accumulated enough profits, they cannot exploit economies of scale, and they have fewer physical assets compared to larger firms (Fort et al., 2013). Nevertheless, large firms with high asset value can apply for external credit without being rejected

**Fig. 7** Average share of innovative firms. Source: calculated by the authors using data from WBES



**Fig. 8** Average share of firms' innovation level by income level. Source: calculated by the authors using data from WBES

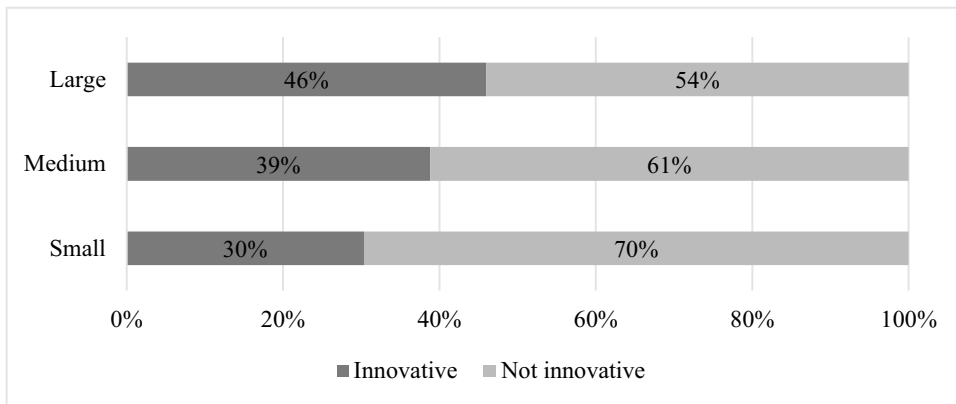
because they have sufficient collateral (Czarnitzki & Hottenrott, 2011).

### 3.2.3 Firms' innovation level

Innovative investments are related to uncertainty because they do not yield instantaneous returns; however, they yield long-term returns (Kerr & Nanda, 2015). Therefore, firms with high productivity are more likely to have

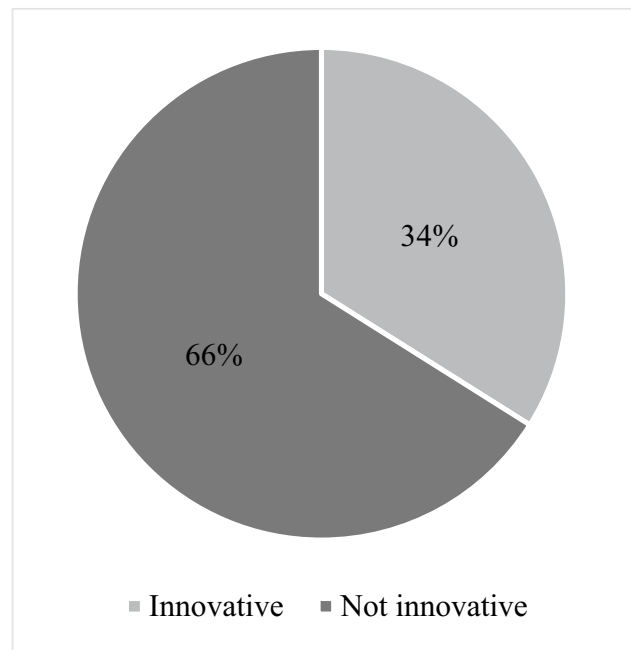
innovative investments. This is highlighted in Fig. 7 which shows that only 36% of firms in the survey innovate, while around two-thirds of firms do not innovate. Similarly, Fig. 8 extends the analysis by income level. It shows that about one-third of firms, whether operating in high-, middle- or low-income countries, are innovative.

Innovation increases with the size of the firm as illustrated in Fig. 9. Large firms are more inclined to invest in innovation because they may be able to



**Fig. 9** Average share of firms' innovation level by firm size. Source: calculated by the authors using data from WBES

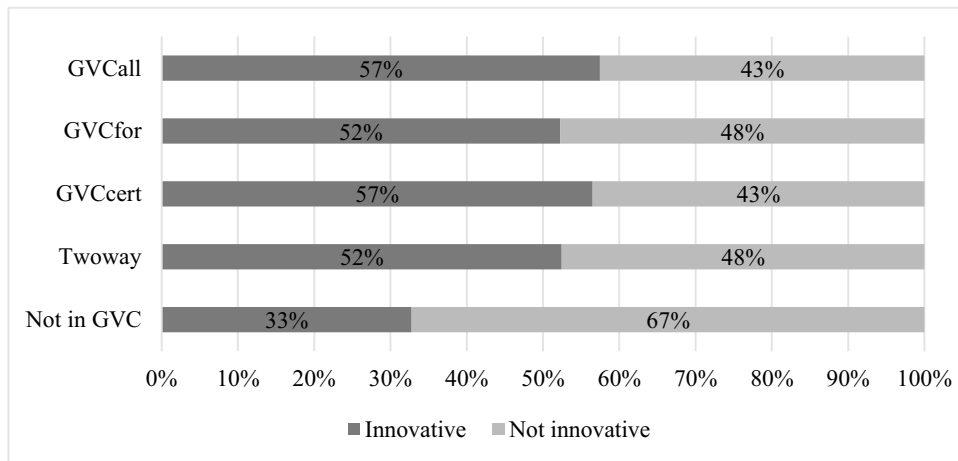
**Fig. 10** Average share of innovation of firms having financial constraints. Source: calculated by the authors using data from WBES



finance most of their projects internally. And if they rely on external sources of finance, they face less restrictions and their investment projects are rarely discarded compared to small firms. However, small firms are the least innovative because it is more difficult for them to exploit scale economies. Additionally, they face more internal and external impediments that prevent them from innovating compared to large firms (Czarnitzki & Hottenrott, 2011).

### 3.2.4 The relationship between financial constraint, GVC participation, and innovation level

Figure 10 proves that two-thirds of firms having financial constraints do not innovate, and only one-third of these firms innovate. Financially constrained firms may abandon some projects because their financial position would not allow them to finalize them, and it will be more difficult for them to obtain external



**Fig. 11** Average share of firms' innovation level by degree of GVC integration. Source: calculated by the authors using data from WBES

financing (Chundakkadan & Sasidharan, 2019), or they may not undertake innovative projects at all.

Figure 11 compares between innovation level of firms participating in GVCs and those which are not integrated in GVCs. It shows that more than half of firms participating in GVC innovate and introduce new products to the market. Nevertheless, only one-third of firms that do not participate in GVCs are innovative.

#### 4 Empirical model

To estimate the effect of financial constraints and GVC participation on the probability of innovation, two main issues need to be addressed. First, the endogeneity problem that results from two reverse causality problems: the first is between financial constraints and innovation and the second is between GVC participation and innovation. Then, possible self-selection problem should be solved. Self-selection means that only the more innovative firms can afford the costs of participating in GVCs, therefore firms may self-select to participate in GVCs.

Therefore, this paper uses the non-linear extended probit model to examine these relationships. This model has several benefits that allow deriving consistent and unbiased estimators of the effect of financial constraints and GVC participation on innovation. First, it has the advantage of accounting for

endogeneity of financial constraints and GVC participation unlike the classical probit model. Second, extended probit model can include more than one endogenous variable which are financial constraints and GVC. Third, unlike instrumental variable probit model, it allows the use of binary endogenous regressors since financial constraints and GVC variables are dummy variables. Fourth, it has a unique feature of handling the use of endogenous covariates in interaction (StataCorp., 2021). Therefore, extended probit model is the best fit in this case and it is represented as follows:

Three sets of equations will be estimated:

First, the model estimates the effect of GVC participation on innovation

$$Y_{i,j,t} = \beta_0 + \beta_1 GVC_{i,j,t} + \beta_2 X_{i,j,t} + \delta_j + \delta_r + \delta_k + \delta_t + \varepsilon_{i,j,t} \quad (1)$$

Second, the model estimates the effect of financial constraints on innovation

$$Y_{i,j,t} = \theta_0 + \theta_1 FC_{i,j,t} + \theta_2 X_{i,j,t} + \delta_j + \delta_r + \delta_k + \delta_t + \mu_{i,j,t} \quad (2)$$

Finally, it focuses on the case of a firm having financial constraints and participating in a GVC and estimate this effect on innovation as follows:

$$Y_{i,j,t} = \lambda_0 + \lambda_1 FC_{i,j,t} + \lambda_2 GVC_{i,j,t} + \lambda_3 FC_{i,j,t} \times GVC_{i,j,t} + \lambda_4 X_{i,j,t} + \delta_j + \delta_r + \delta_k + \delta_t + v_{i,j,t} \quad (3)$$

with  $i$ ,  $j$ , and  $t$  representing firm, country, and time, respectively.

$Y_{i,j,t}$  is firm's innovation level which is measured as a dummy variable taking the value 1 if the firm introduced a new product or service in the market over the last three years, and 0 otherwise.

$GVC_{i,j,t}$  takes into consideration different dimensions of GVC by using four different dummy variables.

- *Two way*: takes the value 1 if the firm exports and imports simultaneously and 0 otherwise
- *GVC cert*: takes the value 1 if the firm exports and has an international quality certification and 0 otherwise
- *GVC for*: takes the value 1 if the firm exports, imports and has a foreign ownership and 0 otherwise
- *GVC all*: takes the value 1 if the firm exports, imports, has an international quality certification and has a foreign ownership and 0 otherwise

According to the literature, estimating the effect of GVC on innovation may lead to reverse causality problem. Thus, a vector of instruments  $Z_{i,j,t}$  is employed to solve the endogeneity problem.  $Z_{i,j,t}$  represents the vector of instruments used which are, first, a dummy variable taking the value 1 if the firm perceives customs and trade regulations as the biggest obstacle, and 0 otherwise. Second, a dummy variable is used taking the value 1 if the firm perceives tax administration as the biggest obstacle, and 0 otherwise. These instruments are chosen since they are directly correlated to GVC participation, because a firm that is participating in the international market and that is part of a GVC is directly affected by obstacles facing the tax system or the trade regulations. Moreover, they satisfy the exclusion restriction assumption since they do not directly affect innovation, but they affect it only through GVC participation. This has been proved by Oudgou (2021) who finds no significant effect when assessing the effect of these obstacles on firm's innovation level. Furthermore, these instruments are relevant and valid as presented in Table 10 in Appendix, as they are exogenous and over-identified for the four definitions of GVC participation.

$FC_{i,j,t}$  is a measurement of credit constraint that is presented in two ways: factual-based and

perception-based. The factual-based financial constraints will be estimated as a dummy variable taking the value 1 if the firm is partially or fully credit constrained, and it takes the value 0 if the firm is not or maybe credit constrained. As for the perception-based financial constraints, it is a dummy variable taking the value 1 if the firm perceives access to finance as the biggest obstacle, and 0 otherwise. According to the literature, reverse causality may also exist between financial constraints and innovation. Therefore, instrumental variable approach is used.  $W_{i,j,t}$  is the vector of instruments used to solve the endogeneity between the two variables. It includes two instruments: the first instrument represents overdraft facility<sup>6</sup> which is a dummy variable equal to 1 if a firm has an overdraft facility, and 0 otherwise. Overdraft facility variable is proved to be relevant because it is highly correlated to financial constraints. It is also proved to be exogenous because it only affects innovation through financial constraints. This can be explained by the fact that since it is difficult for financial institutions to provide firms with loans to finance their innovation, so it is even more difficult to provide overdraft facilities—which are only available for a shorter period—for innovation financing (Chundakadan & Sasidharan, 2019; Oudgou, 2021).

The second instrument is the percentage value of products lost in transit due to theft. It is considered as valid instrument because it represents an unexpected and exogenous shock to firms' cash flows and internal funds. Thus, it directly affects firm's cash flow and financial situation, but it does not directly affect its innovation (Ayalew & Xianzhi, 2019; Gómez-Ramírez, 2019; Gorodnichenko & Schnitzer's, 2013). By testing for the validity of the instruments, the two instruments are exogenous and over-identified for the two definitions of financial constraints—the factual-based and the perception-based—as shown in Table 11 in Appendix.

<sup>6</sup> An overdraft line of credit is a short-term method of financing provided by banks after evaluating a firm's credit worthiness; it has a higher interest rate compared to loans. It has been widely used in the literature as an instrument for financial constraints since it is considered as a short-term loan that can never be offered to firms to finance their innovative investments or their R&D projects; hence, it does not affect innovation, but it has direct effect on financial constraints.

**Table 2** Extended probit model for the effect of GVC participation on innovation

	Extended probit			
	(1)	(2)	(3)	(4)
	Innovation	Innovation	Innovation	Innovation
Two-way	0.782*** (0.153)			
GVC certification		0.797*** (0.220)		
GVC foreign			0.654*** (0.205)	
GVC all				0.716*** (0.242)
Capacity utilization	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Employment growth	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Informal competent	0.191*** (0.074)	0.180** (0.077)	0.172** (0.073)	0.166** (0.071)
Medium	0.197*** (0.018)	0.211*** (0.018)	0.239*** (0.018)	0.240*** (0.019)
Large	0.346*** (0.022)	0.359*** (0.022)	0.452*** (0.022)	0.452*** (0.022)
corr(e.twoway,e.innov)	-0.253*** (0.091)			
corr(e.GVCcert,e.innov)		-0.202* (0.116)		
corr(e.GVCfor,e.innov)			-0.221** (0.097)	
corr(e.GVCall,e.innov)				-0.197* (0.103)
Observations	46,939	46,879	47,594	47,576

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem

$X_{i,j,t}$  is a vector of control variables including firms' characteristics representing size, capacity utilization, annual employment growth rate, and whether the firm competes against unregistered or informal firms.  $\delta_j$ ,  $\delta_r$ ,  $\delta_k$ , and  $\delta_t$  are the country, region, industry, and year fixed effect, respectively.

This model controls for heterogeneity among firms (by country, region, and industry), different firms' characteristics, and reverse causality.

## 5 Empirical findings and policy recommendations

This part shows the results of the individual effects of GVC participation on innovation and those of

financial constraints on innovation, followed by the interaction between both variables and their effect on innovation. The model is then extended by examining the relationship for different income groups.

### 5.1 The effect of GVC participation on innovation

The results in Table 2 show that the coefficients of the four definitions of GVC participation are positive and significant after solving the endogeneity problem using the extended probit model. This means that firms which are two-way traders and have quality certification and foreign ownership have higher probability to innovate than other firms which do not participate in GVCs. These results are in line with the

literature since GVC participation leads to an international division of labor which decreases firms' trade costs and increases their trade gains (Tajoli & Felice, 2018). Thus, firms start to form a trade network, and acquire know-how, which is reflected in better technologies and innovations (Gereffi, 2014). Consequently, firms may either imitate technologies used by foreign firms (Dang & Dang, 2020), or they may independently improve and upgrade their products and processes (Humphrey & Schmitz, 2002). In all cases, this leads to an improvement in their level of innovation.

The effect of GVC participation on innovation is robust to the inclusion of the set of covariates. As for the employment growth, the results show that firms with a growing number of employees have higher probability to invest in product innovation compared to other firms having constant or decreasing growth of employees which is in line with Okumu et al., (2019). Moreover, firms competing against informal or unregistered firms have higher incentives to innovate and to be more productive, as shown also by Boldrin and Levine (2008). Furthermore, informal firms face lower costs; thus, formal firms must improve their products to surpass informal and unregistered firms as proved by Ali and Najaman (2015). It is also worth mentioning that the effect of GVCs is greater for large firms compared to medium and small firms. When firms increase in size and in number of employees, their ability to invest more in innovation also increases; they also improve existing products and introduce new products compared to small firms (Brancati et al., 2017; Dang & Dang, 2020).

## 5.2 The effect of financial constraints on innovation

Empirically, this paper compares between two measurements of financial constraints—factual-based and perception-based. This comparison aims to test if there is a difference between the real figures of financial constraints and the level of constraints that the firm thinks it faces.

The results of financial constraints—factual-based and perception-based definitions—are negative and significant as shown in Table 3. These results are in line with the literature that proves that firms' decisions to invest in innovative activities is sensitive to financial constraints (Gorodnichenko & Schnitzer, 2013). Firms' financial constraints reduce firms'

**Table 3** Extended probit model for the effect of financial constraints (using both definitions) on innovation

	Extended probit	
	<i>Factual-based</i> (1)	<i>Perception-based</i> (2)
	Innovation	Innovation
FC	−1.311*** (0.086)	−1.323*** (0.105)
Capacity utilization	−0.003*** (0.001)	−0.003*** (0.001)
Employment growth	0.001 (0.001)	0.003*** (0.001)
Informal competent	0.169* (0.09)	0.134* (0.069)
Medium	0.160*** (0.025)	0.197*** (0.021)
Large	0.324*** (0.043)	0.399*** (0.029)
corr(e.fact,e.innov)	0.833*** (0.102)	
corr(e.perc,e.innov)		0.735*** (0.068)
Observations	43,514	42,914

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem

probability to invest in new products, because it is difficult for constrained firms to fund innovative investments through external sources or internal sources of finance. As for the external sources, banks will not finance new technologies of a financially constrained firm. For banks to finance new technologies, they must have low uncertainty, low moral hazard, low information asymmetry problems, and low risks of failure. Moreover, they must receive high collaterals. Thus, they will only finance firms which have high financial capabilities and do not face financial constraints (Ayalew & Xianzhi, 2019). Furthermore, firms cannot rely on their internal sources of financing when they are financially constrained because they will not be able to accumulate profits that would allow them to conduct R&D projects (Czarnitzki & Hottenrott, 2011).



The results are robust to the inclusion of control variables. Capacity utilization reduces the probability of innovation. When firms aim to improve their capacity utilization, their main interest becomes to implement strategies that lead to systemic rigidity and disregard introducing new products and services in the market (Fevolden & Grønning, 2010).

### 5.3 The effect of the interaction between GVC and financial constraints on innovation

This part shows the interaction between GVC participation and financial constraints and their effect on innovation. It focuses first on firms participating in GVCs, having financial constraints, and how this interaction affects their innovation activities, as shown in the first 4 columns of Table 4. Then, it studies firms that integrate GVC and perceive themselves as having financial constraints and their effect on innovative investments, as illustrated in columns 5, 6, 7 and 8 of Table 4.

The results of the first four columns show that the coefficient of GVC participation is positive and significant, and the coefficient of factual definition of financial constraints is negative and significant. These results confirm the findings of the individual effects and are in line with the literature.

As for the interactions of financial constraints with all the definitions of GVC participation, the results show a negative coefficient. This means that firms participating in GVCs but having high financial constraints are less likely to innovate. Thus, the presence of financial constraints reduces the positive effect of GVC participation on innovation. The effect is negative and significant for the first two definitions of GVC, but it is negative and not significant for the third and fourth definitions.

These results are in line with the literature proving that firms participating in GVC may face risks which can aggravate their financial status. These risks may be related to the volatility of exchange rate and the additional costs that they must bear to join the international market (Van Biesebroeck, 2014). Moreover, financial constraints are more likely to affect firm's export status (Gorodnichenko & Schnitzer, 2013). These financial difficulties are considered as a severe obstacle that impede firms' innovative growth.

Columns 5, 6, 7, and 8 shows the results for the perception-based definition of financial constraints. As for the interactions between GVC and the

perception of financial constraints, it shows a negative and significant coefficient. This means that firms' integrating GVC and perceiving themselves as having financial constraints as their major obstacle have lower probability to invest in innovative activities or to introduce products to the market.

### 5.4 Model extensions

Although the sample consists of developing countries, their level of GVC participation, financial constraints, and innovation differ by income level. In this context, Table 5 compares the effect of financial constraints and GVCs on innovation in low-, middle-, and high-income countries.

The results of the middle-income group are robust to the results of Table 4. Thus, the overall results of the model are driven by the middle-income group, since most of the countries in the dataset are middle-income countries. GVC participation tends to benefit middle-income countries the most.

Several middle-income countries are endowed with cheap labor. They also tend to produce products with cheap prices and with relatively good quality. This results in increased productivity and improved technological level (Henn et al., 2020). Therefore, firms in these countries start to participate in GVCs which increase their growth rates and their innovative investments (World Bank, 2019).

Moreover, middle-income countries try to escape the middle-income trap. Thus, they tend to acquire a comparative advantage in more sophisticated products and move to higher value-added stages (Engel & Taglioni, 2017). Specializing in these high value-added tasks involves high technologies and high levels of R&D, which has a positive spillover on technological upgrading (UNESCAP, 2015).

For example, China is a middle-income country that participates in high technology and manufacturing processes (Antras, 2019). It tends to participate in downstream activities to be able to create high value in the eyes of the end-consumer. It has the benefit of having the lowest trade costs in Asia, in addition to the advantage of having low tariff rates which reduce its prices in the international market. Moreover, it is endowed with cheap labor force. These endowments, in addition to its focus on downstream activities, generate a distinctive opportunity for industrialization in China, facilitate its participation in GVCs, and incite

**Table 4** Extended probit model for the effect of participating in GVCs and suffering from financial constraints (factual-based and perception-based) on innovation

	Extended probit <i>Factual-based</i>				Extended probit <i>Perception-based</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation
Two-way	0.690*** (0.136)				0.747*** (0.128)			
GVC certification		0.697*** (0.267)				0.779*** (0.183)		
GVC foreign			0.599*** (0.208)				0.714*** (0.196)	
GVC all				0.648*** (0.230)				0.794*** (0.195)
FC	-1.241*** (0.071)	-1.273*** (0.074)	-1.295*** (0.086)	-1.299*** (0.086)	-1.279*** (0.105)	-1.304*** (0.105)	-1.335*** (0.093)	-1.341*** (0.093)
Two-way × FC	-0.161*** (0.042)				-0.223*** (0.046)			
GVC certification × FC		-0.161*** (0.064)				-0.207*** (0.079)		
GVC foreign × FC			-0.133 (0.089)				-0.331*** (0.072)	
GVC all × FC				-0.148 (0.109)				-0.367*** (0.107)
Capacity utilization	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)
Employment growth	0.001 (0.001)	0.001 (0.001)	0.0005 (0.001)	0.001 (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Informal competent	0.187** (0.094)	0.183* (0.100)	0.173* (0.095)	0.170* (0.095)	0.163** (0.074)	0.158** (0.077)	0.150** (0.071)	0.146** (0.071)
Medium	0.127*** (0.017)	0.137*** (0.019)	0.156*** (0.024)	0.158*** (0.024)	0.153*** (0.017)	0.165*** (0.019)	0.188*** (0.02)	0.189*** (0.020)
Large	0.224*** (0.023)	0.233*** (0.025)	0.301*** (0.038)	0.302*** (0.038)	0.278*** (0.021)	0.289*** (0.022)	0.367*** (0.025)	0.368*** (0.025)
Observations	40,689	40,616	41,235	41,219	42,202	42,130	42,794	42,772

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem

it to upgrade its industrial structure to higher levels of technology (Huang, 2016; UNCTAD, 2015).

Nevertheless, the effect of GVC participation in high-income countries tends to be unclear. On the one hand, they try to takeover multi-stages of production to decrease cross-hauling, so they focus on upstream stages. On the other hand, they focus sometimes on the downstream stages and have higher backward

GVC integration in order to be close to the final demand and to the end consumer (Antras, 2019). Thus, when firms engage in more downstream stages, they are more likely to innovate. However, when they participate in forward GVCs, they innovate less (UNESCAP, 2015). This may explain the non-significant effect of GVC participation on innovation in high-income countries.

**Table 5** The effect of GVC participation of firms having financial constraints (factual-based) on innovation by income group

	Low-income			Middle-income			High-income					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Two-way	0.593 (0.722)				0.762*** (0.095)				0.089 (0.592)			
GVC certification		1.606*** (0.282)				0.806*** (0.161)				0.403 (2.370)		
GVC foreign			-0.166 (0.994)				0.747*** (0.157)				-0.513 (0.360)	
GVC all				1.896*** (0.112)				0.787*** (0.145)				0.313 (1.130)
FC	-0.683** (0.323)	-0.671** (0.313)	-0.725** (0.303)	-0.643*** (0.0708)	-1.273*** (0.0344)	-1.295*** (0.0381)	-1.315*** (0.0472)	-1.318*** (0.0476)	-1.195*** (0.167)	-1.214*** (0.156)	-1.264*** (0.195)	-1.312*** (0.192)
Two-way×FC	-0.276* (0.167)				-0.121*** (0.0377)				-0.179*** (0.086)			
GVC certification×FC		0.0786 (0.342)				-0.114** (0.053)				-0.155 (0.186)		
GVC foreign×FC			0.0325 (0.212)				-0.130 (0.081)				-0.0381 (0.143)	
GVC all×FC				0.659*** (0.143)				-0.120 (0.099)				-0.108 (0.153)
Observations	1,516	1,506	1,515	1,515	33,508	33,454	34,031	34,013	5,665	5,656	5,689	5,691

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Control variables and constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem

As for financial constraints, it tends to reduce innovation for all income categories which is consistent with the literature. Several middle-income countries such as Argentina, Brazil, China, and Nigeria have faced high debt problems in the aftermath of the great recession. These problems made them financially unstable and more vulnerable to unexpected shocks and have slowed down their activity which has declined their innovation level (IMF, 2016).

As for the interaction between firms participating in GVCs and having financial constraints, they tend to give similar results to Table 4. This means that financial constraints reduce the positive effects of GVC participation on firms' probability to innovate.

## 6 Robustness checks

This section tests whether the results of Table 4 still hold after accounting for possible self-selection, although the sample is not restricted to innovative firms participating in GVCs. This paper follows Reddy et al. (2021) in running a two-step probit selection model to correct for the self-selection issue. Following Montalbano et al. (2018) and Reddy et al. (2021), the paper uses firm size as an exclusion restriction to generate the inverse mills ratio and it complements this with instrumental variables approach.

Table 6 presents the findings of the two-step probit selection model. The results show that the coefficient of the inverse mills ratio is always negative and significant across all the specifications, pointing to selection bias in the sample. After correcting for the self-selection bias and the endogeneity problems, the main results are still robust.

The paper also tests whether the results of Table 4 still hold when using an alternative measurement of innovation, namely the firm's R&D expenditures. Firm's R&D expenditures is used as a dummy variable taking the value 1 if the firm spends money on R&D projects during the last fiscal year and 0 otherwise.

Second, two new measurements of financial constraints are considered, a new measurement for the factual-based definition and a new one for the perception-based definition. As for the factual-based variable, another dummy variable is used based on the methodology of Kuntchev et al. (2013) taking the value 1 if the firm is FCC and taking the value 0 if the firm is NCC, MCC, or PCC. Thus, the main focus is on the

category of firms that cannot get any source of external finance, and that do not apply for loans, or whose loans get rejected. All the results are still robust. As for the perception-based measurement of financial constraints, following De Haas et al. (2018), a dummy variable is created having the value 1 if the firm perceives access to finance as a "major" or "very severe" obstacle, and the value 0 if the firm perceives access to finance as "no obstacle," "minor obstacle," or "moderate obstacle." The results are also still robust.

Finally, the effect of the interaction between GVC participation and the new measurements of financial constraints on R&D spending is assessed, and the results are still robust.<sup>7</sup> It is also worth mentioning that all the results are robust to the inclusion or exclusion of all the fixed effects. To conclude, the results of Table 4 are robust to different innovation proxies, and to different measurements of financial constraints.

## 7 Conclusion

This paper studies the effect of firms participating in GVC and facing financial constraints on their probability of innovation. By using data from WBES between 2006 and 2020, extended probit model is used. This model controls for heterogeneity among firms (by country, region, and industry), sample selection, firms' characteristics, and reverse causality.

The empirical findings show that participating in a GVC represents an opportunity for a firm to increase its probability to innovate. However, financial constraints are considered as an obstacle hindering the firm's ability to innovate. The results reinforce the notion that the firm's behavior in the international market affects its innovation capacity. Moreover, as for firms that are participants in GVC and that face financial constraints, they have lower probabilities to invest in R&D projects or introduce new products in the market because the negative effects of financial constraints outweigh the positive effects of GVC participation on innovation. Therefore, firms need to have good financial structure to enter the international market. Finally, the findings show the importance of large and medium firms compared to small firms, when considering it comes to their probability to innovate.

<sup>7</sup> All the results are reported in Tables 12, 13, and 14 in the Appendix.

**Table 6** IV-Heckprobit with sample correction for the effect of participating in GVCs and suffering from financial constraints (factual-based and perception-based) on innovation

Variables	Factual-based FC				Perception-Based FC			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Two-way	0.316*** (0.0371)				0.352*** (0.0248)			
GVC certification		0.349*** (0.0436)				0.395*** (0.0317)		
GVC foreign			0.166*** (0.0307)				0.210*** (0.0325)	
GVC all				0.216*** (0.0341)				0.277*** (0.0372)
FC	-1.285*** (0.0903)	-1.300*** (0.0842)	-1.315*** (0.0792)	-1.316*** (0.0797)	-1.310*** (0.102)	-1.324*** (0.102)	-1.341*** (0.0945)	-1.343*** (0.0950)
Two-way × FC	-0.110*** (0.0317)				-0.211*** (0.0439)			
GVC certification × FC		-0.0811** (0.0371)				-0.185*** (0.0709)		
GVC foreign × FC			-0.0716 (0.0634)				-0.275*** (0.0726)	
GVC all × FC				-0.0548 (0.0772)				-0.304*** (0.0988)
Inverse mills ratio	-0.240*** (0.0278)	-0.193*** (0.0235)	-0.264*** (0.0328)	-0.236*** (0.0294)	-0.302*** (0.0221)	-0.242*** (0.0184)	-0.324*** (0.0217)	-0.290*** (0.0197)
Capacity utilization	-0.003*** (0.0008)	-0.003*** (0.0009)	-0.003*** (0.0009)	-0.003*** (0.0009)	-0.003*** (0.0007)	-0.003*** (0.0008)	-0.003*** (0.0008)	-0.003*** (0.0008)
Employment growth	0.00115 (0.0008)	0.00118 (0.0008)	0.00107 (0.0008)	0.00144* (0.0008)	0.00310*** (0.0007)	0.00310*** (0.0007)	0.00306*** (0.0007)	0.00347*** (0.0007)
Informal competent	0.206** (0.0910)	0.206** (0.0943)	0.235** (0.0968)	0.229** (0.0963)	0.177*** (0.0681)	0.177** (0.0710)	0.215*** (0.0711)	0.207*** (0.0709)
Observations	42,810	42,740	43,388	43,375	42,202	42,130	42,794	42,772

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects and account for possible endogeneity of FCs. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0. (vii) The results are robust to the inclusion of different instruments of GVCs

Therefore, encouraging small firms to integrate into GVCs may affect the probability of innovation.

These findings have important policy implications. Governments should use several policies to encourage firms' participation in GVCs due to their positive effect on the economy. Thus, removing any barrier preventing their participation is of utmost importance. Therefore, policymakers may intervene and develop financial markets by ensuring access to external finance for firms participating in GVCs. They may also facilitate lending and financing procedures by providing firms integrating

GVCs with financial assistance, or by offering loans to these firms with easier terms. However, this strategy should not neglect a careful screening and monitoring process. Moreover, governments may provide tax incentives, such as R&D tax allowance or R&D tax credit incentives, to nascent participants in GVCs to encourage them to innovate. They may also encourage firms' innovation by lowering tax rates for firms with worldwide known innovations. Finally, governments may provide non-financial assistance to firms in form of trainings and assistance programs.

## Appendix 1 List of countries, years, and number of firms

**Table 7** Countries, years, and number of firms in the sample

Country	Survey years	Number of firms	Percent of total number of firms
Afghanistan	2008, 2014	945	0.56%
Albania	2007, 2013, 2019	1041	0.61%
Angola	2006, 2010	785	0.46%
Antigua and Barbuda	2010	151	0.09%
Argentina	2006, 2010, 2017	3108	1.83%
Armenia	2009, 2013, 2020	1280	0.75%
Azerbaijan	2009, 2013, 2019	995	0.59%
Bahamas	2010	150	0.09%
Bangladesh	2007, 2013	2946	1.73%
Barbados	2010	150	0.09%
Belarus	2008, 2013, 2018	1233	0.73%
Belgium	2020	614	0.36%
Belize	2010	150	0.09%
Benin	2009, 2016	300	0.18%
Bhutan	2009, 2015	503	0.30%
Bolivia	2006, 2010, 2017	1339	0.79%
Bosnia and Herzegovina	2009, 2013, 2019	1083	0.64%
Botswana	2006, 2010	610	0.36%
Brazil	2009	1802	1.06%
Bulgaria	2007, 2009, 2013, 2019	2368	1.39%
Burkina Faso	2009	394	0.23%
Burundi	2006, 2014	427	0.25%
Cambodia	2013, 2016	845	0.50%
Cameroon	2009, 2016	724	0.43%
Cape Verde	2009	156	0.09%
Central African Republic	2011	150	0.09%
Chad	2009, 2018	303	0.18%
Chile	2006, 2010	2050	1.21%
China	2012	2700	1.59%
Colombia	2006, 2010, 2017	2935	1.73%
Congo	2009	151	0.09%
Costa Rica	2010	538	0.32%
Côte d'Ivoire	2009, 2016	887	0.52%
Croatia	2007, 2013, 2019	1397	0.82%
Cyprus	2019	240	0.14%
Czech Republic	2009, 2013, 2019	1006	0.59%
Djibouti	2013	266	0.16%
Dominica	2010	150	0.09%
Dominican Republic	2010, 2016	719	0.42%
DRC	2006, 2010, 2013	1228	0.72%
Ecuador	2006, 2010, 2017	1385	0.82%
Egypt	2013, 2016, 2020	7786	4.58%

**Table 7** (continued)

Country	Survey years	Number of firms	Percent of total number of firms
El Salvador	2006, 2010, 2016	1772	1.04%
Eritrea	2009	179	0.11%
Estonia	2009, 2013, 2019	906	0.53%
Eswatini	2006, 2016	457	0.27%
Ethiopia	2011, 2015	1492	0.88%
Fiji	2009	164	0.10%
Gabon	2009	179	0.11%
Gambia	2006, 2018	325	0.19%
Georgia	2008, 2013, 2019	1314	0.77%
Ghana	2007, 2013	1214	0.71%
Greece	2018	600	0.35%
Grenada	2010	153	0.09%
Guatemala	2006, 2010, 2017	1457	0.86%
Guinea	2006, 2016	373	0.22%
Guinea Bissau	2006	159	0.09%
Guyana	2010	165	0.10%
Honduras	2006, 2010, 2016	1128	0.66%
Hungary	2009, 2013, 2019	1406	0.83%
India	2014	9281	5.46%
Indonesia	2009, 2015	2764	1.63%
Iraq	2011	756	0.44%
Israel	2013	483	0.28%
Italy	2019	760	0.45%
Jamaica	2010	376	0.22%
Jordan	2013, 2019	1174	0.69%
Kazakhstan	2009, 2013, 2019	2590	1.52%
Kenya	2007, 2013, 2018	2439	1.44%
Kosovo	2009, 2013, 2019	743	0.44%
Kyrgyz Republic	2009, 2013, 2019	865	0.51%
Lao PDR	2009, 2012, 2016, 2018	1330	0.78%
Latvia	2009, 2013, 2019	966	0.57%
Lebanon	2013, 2019	1093	0.64%
Lesotho	2009, 2016	301	0.18%
Liberia	2009, 2017	301	0.18%
Lithuania	2009, 2013, 2019	904	0.53%
Luxembourg	2020	170	0.10%
Madagascar	2009, 2013	977	0.57%
Malawi	2009, 2014	673	0.40%
Malaysia	2015	1000	0.59%
Mali	2007, 2010, 2016	1035	0.61%
Malta	2019	242	0.14%
Mauritania	2006, 2014	387	0.23%
Mauritius	2009	398	0.23%
Mexico	2006, 2010	2960	1.74%
Micronesia	2009	68	0.04%
Moldova	2009, 2013, 2019	1083	0.64%

**Table 7** (continued)

Country	Survey years	Number of firms	Percent of total number of firms
Mongolia	2009, 2013, 2019	1082	0.64%
Montenegro	2009, 2013, 2019	416	0.24%
Morocco	2013, 2019	1503	0.88%
Mozambique	2007, 2018	1080	0.64%
Myanmar	2014, 2016	1239	0.73%
Namibia	2006, 2014	909	0.53%
Nepal	2009, 2013	850	0.50%
Nicaragua	2006, 2010, 2016	1147	0.67%
Niger	2009, 2017	301	0.18%
Nigeria	2007, 2014	4567	2.69%
North Macedonia	2009, 2013, 2019	1086	0.64%
Pakistan	2007, 2013	2182	1.28%
Panama	2006, 2010	969	0.57%
Papua New Guinea	2015	65	0.04%
Paraguay	2006, 2010, 2017	1338	0.79%
Peru	2006, 2010, 2017	2635	1.55%
Philippines	2009, 2015	2661	1.57%
Poland	2009, 2013, 2019	2366	1.39%
Portugal	2019	1062	0.62%
Romania	2009, 2013, 2019	1895	1.12%
Russia	2009, 2012, 2019	6547	3.85%
Rwanda	2006, 2011, 2019	813	0.48%
Samoa	2009	109	0.06%
Senegal	2007, 2014	1107	0.65%
Serbia	2009, 2013, 2019	1109	0.65%
Sierra Leone	2009, 2017	302	0.18%
Slovak Republic	2009, 2013, 2019	972	0.57%
Slovenia	2009, 2013, 2019	955	0.56%
Solomon Islands	2015	151	0.09%
South Africa	2007, 2020	2034	1.20%
South Sudan	2014	738	0.43%
Sri Lanka	2011	610	0.36%
St Kitts and Nevis	2010	150	0.09%
St Lucia	2010	150	0.09%
St Vincent and Grenadines	2010	154	0.09%
Sudan	2014	662	0.39%
Suriname	2010, 2018	385	0.23%
Sweden	2014	600	0.35%
Tajikistan	2008, 2013, 2019	1071	0.63%
Tanzania	2006, 2013	1232	0.72%
Thailand	2016	1000	0.59%
Timor-Leste	2009, 2015	276	0.16%
Togo	2009, 2016	305	0.18%
Tonga	2009	150	0.09%
Trinidad and Tobago	2010	370	0.22%
Tunisia	2013, 2020	1207	0.71%



**Table 7** (continued)

Country	Survey years	Number of firms	Percent of total number of firms
Turkey	2008, 2013, 2019	4159	2.45%
Uganda	2006, 2013	1325	0.78%
Ukraine	2008, 2013, 2019	3190	1.88%
Uruguay	2006, 2010, 2017	1575	0.93%
Uzbekistan	2008, 2013, 2019	1995	1.17%
Vanuatu	2009	128	0.08%
Venezuela	2006, 2010	820	0.48%
Vietnam	2009, 2015	2049	1.21%
West Bank and Gaza	2013, 2019	799	0.47%
Yemen	2010, 2013	830	0.49%
Zambia	2007, 2013, 2019	1805	1.06%
Zimbabwe	2011, 2016	1199	0.71%

Source: calculated by the authors using data from WBES

## Appendix 2 List of variables

**Table 8** Variable definition

Variable	Measurement	Definition
GVC	Two-way	A dummy variable = 1 if the firm is two-way trader
	GVC certification	A dummy variable = 1 if the firm is two-way trader and has a quality certification
	GVC foreign	A dummy variable = 1 if the firm is two-way trader and has a foreign ownership
	GVC all	A dummy variable = 1 if the firm is two-way trader and has a quality certification and a foreign ownership
Tax obstacle		A dummy variable = 1 if the firm perceives tax administration as a major obstacle
Customs and trade obstacles		A dummy variable = 1 if the firm perceives customs and trade regulations as a major obstacle
Financial constraints	Factual-based	A dummy variable = 1 if the firm is partially credit constrained (PCC), or fully credit constrained (FCC)
		As robustness: a dummy variable = 1 if the firm is fully credit constrained (FCC)
	Perception-based	A dummy variable = 1 if the firm perceives access to finance as a major obstacle
		As robustness: a dummy variable = 1 if the firm perceives access to finance as major or very severe obstacle
Overdraft		A dummy variable = 1 if the firm receives an overdraft facility
Value of product lost		A continuous variable representing the value of product lost in transit due to theft
Innovation	Product upgrading	A dummy variable = 1 if the firm introduced a new product or service to the market during the last 3 years
	R&D	A dummy variable = 1 if the firm spent on R&D during the last fiscal year
Capacity utilization		A continuous variable illustrating the percentage of capacity utilization
Employment growth		A continuous variable representing the percentage of annual employment growth
Informal competent		A dummy variable = 1 if the firm is competing against unregistered or informal firms
Region		6 Regions: Africa, East Asia and Pacific, Eastern Europe and Central Asia, Latin American Countries, MENA region, South Asia
Industry		52 Industries encompassing basic metals, chemicals, construction, electronics, food, furniture, garments, tourism, hotels and restaurants, IT, machinery, manufacturing, motor-vehicle, petroleum products, retail, wholesale, services, textiles, transport and wood and their derivatives

Source: by the authors using data from WBES

### Appendix 3 List of survey questions used in the model

**Table 9** List of survey questions used to create the main variables of the model

Measurement	List of questions
GVC	Percent of firms exporting directly or indirectly (at least 1% of sales) Percent of material inputs and supplies of foreign origin in last fiscal year Does establishment have an internationally recognized quality certification? Percentage owned by private foreign individuals, companies, or organizations
Financial constraints Factual-based definition	In last fiscal year, did establishment apply for new loans/lines of credit? Main reason for not applying for new loans or new lines of credit Proportion of working capital financed by external sources (%) Proportion of investments financed by external funds (%) Establishment has a line of credit or loan from a financial institution? Percent of firms whose recent loan application was rejected
Financial constraints Perception-based definition	Percentage of establishments that consider access to finance to be the biggest obstacle How much of an obstacle: access to finance?
Innovation	New products/services introduced over last 3 years? During last fiscal year, establishment spent on R&D (excluding market research)?

Source: WBES

Appendix 4 Obstacles facing firms participating in GVCs

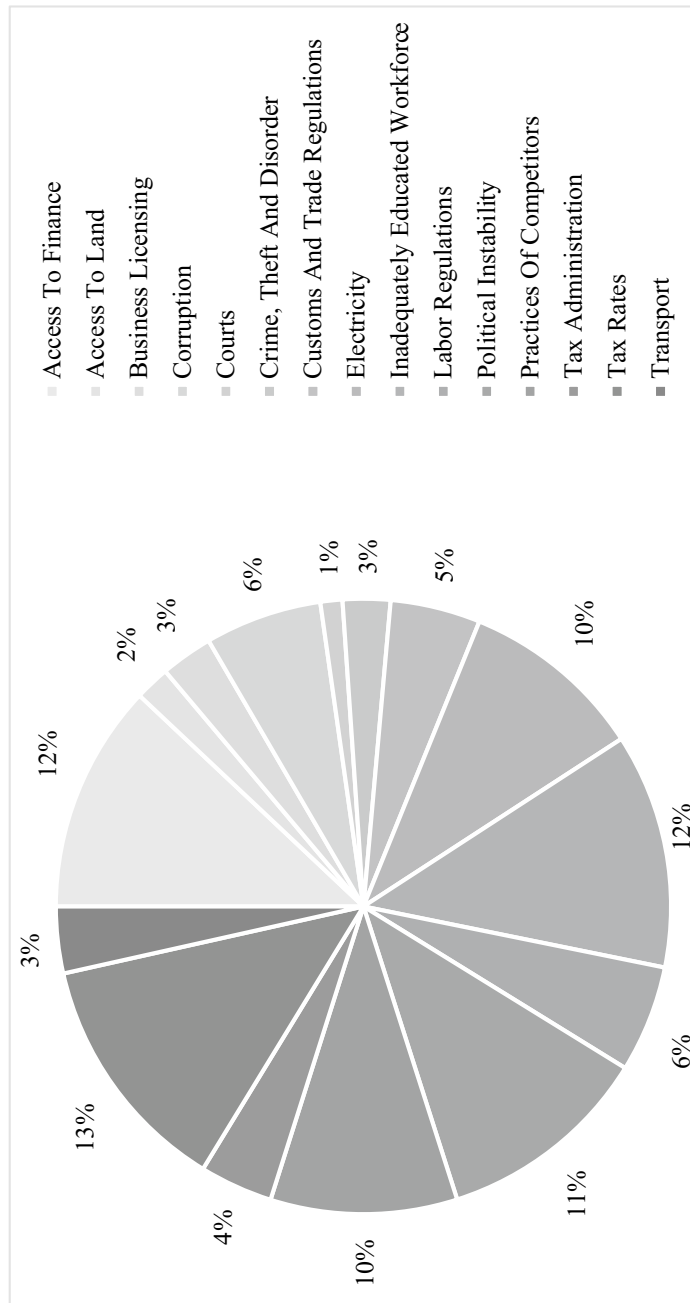


Fig. 12 Biggest obstacles in the business environment (% of firms participating in GVCs). Source: calculated by the authors using WBES

Appendix 5 Factual measurement of financial constraints

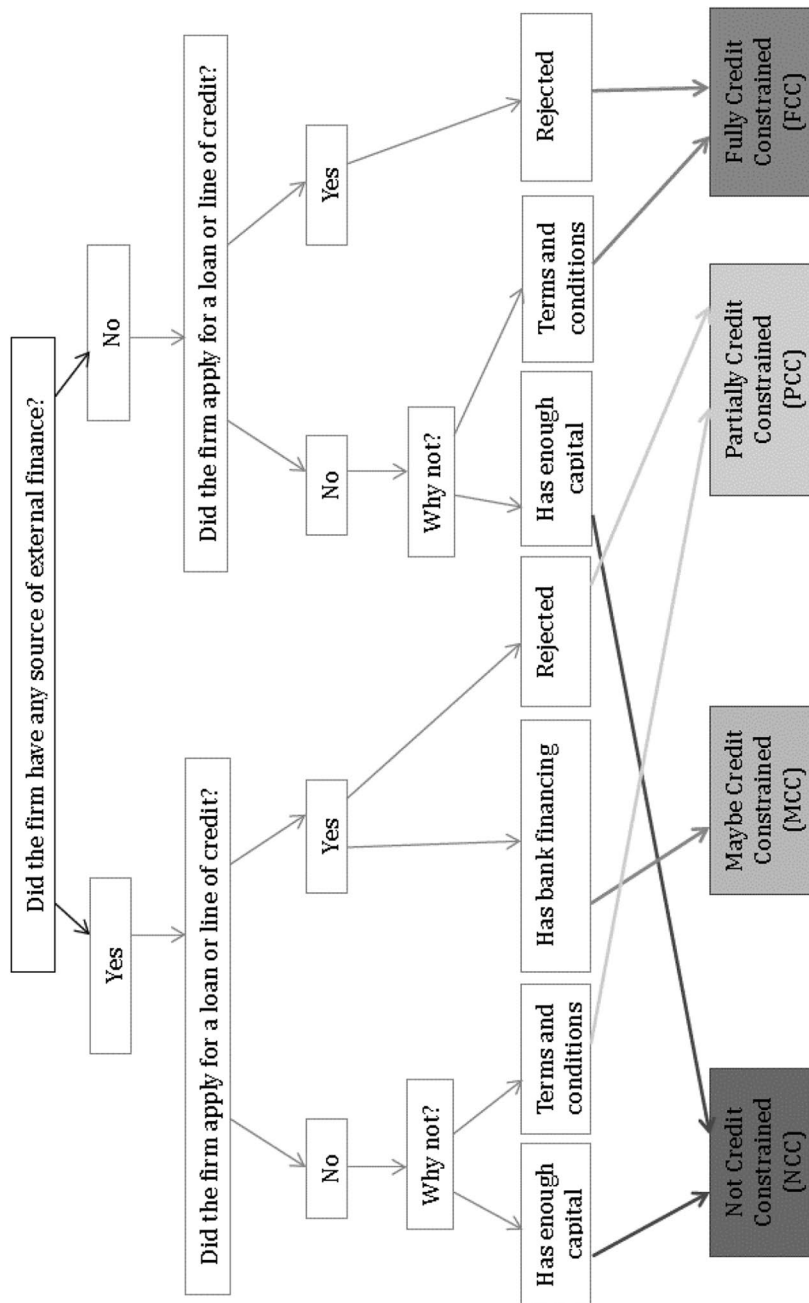


Fig. 13 Classification of firms based on their access to credit. Source: Kunitchev et al. (2013)

## Appendix 6 Instrument testing

**Table 10** Endogeneity test—tax administration obstacles and customs and trade regulation obstacles

	Underidentification test		Sargan stat		Endogeneity test	
	H0: IV not correlated with GVC		H0: instruments are valid		H0: variables are exogenous	
	<i>F</i> stat	<i>p</i> value	<i>F</i> stat	<i>p</i> value	<i>F</i> stat	<i>p</i> value
Two-way	156.333	0.0000	0.168	0.6817	14.697	0.0000
GVC certification	67.269	0.0000	0.437	0.5088	18.374	0.0000
GVC foreign	71.026	0.0000	0.05	0.8224	25.413	0.0000
GVC all	45.236	0.0000	0.026	0.8729	26.561	0.0000

**Table 11** Endogeneity test—overdraft facility and percentage value of products lost in transit due to theft

	Underidentification test		Sargan stat		Endogeneity test	
	H0: IV not correlated with FC		H0: instruments are valid		H0: variables are exogenous	
	<i>F</i> stat	<i>p</i> value	<i>F</i> stat	<i>p</i> value	<i>F</i> stat	<i>p</i> value
Factual-based	231.029	0.0000	0.929	0.3351	329.643	0.0000
Perception-based	12.754	0.0017	1.518	0.2179	299.102	0.0000

## Appendix 7 Robustness checks

**Table 12** The effect of GVC participation and financial constraints (using the two initial definitions) on R&D expenditure

	Extended probit <i>Factual-based</i>				Extended probit <i>Perception-based</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
Two-way	0.732*** (0.187)				0.776*** (0.202)			
GVC certification		0.731*** (0.203)				0.773*** (0.185)		
GVC foreign			0.514** (0.200)				0.550** (0.216)	
GVC all				0.574*** (0.181)				0.677*** (0.206)
FC	-1.224*** (0.045)	-1.274*** (0.036)	-1.303*** (0.041)	-1.309*** (0.04)	-1.352*** (0.057)	-1.413*** (0.038)	-1.429*** (0.047)	-1.440*** (0.043)
Two-way×FC	-0.119** (0.048)				-0.242*** (0.041)			
GVC certification×FC		-0.209*** (0.057)				-0.284*** (0.048)		
GVC foreign×FC			-0.139** (0.062)				-0.287*** (0.079)	
GVC all×FC				-0.230*** (0.081)				-0.502*** (0.101)
Capacity utilization	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)
Employment growth	-4.18e-05 (0.001)	-2.26e-05 (0.001)	-0.0002 (0.001)	-9.97e-05 (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)
Informal competent	0.134 (0.083)	0.133 (0.083)	0.123 (0.076)	0.119 (0.075)	0.094 (0.061)	0.089 (0.058)	0.081 (0.051)	0.078 (0.05)
Medium	0.227*** (0.028)	0.232*** (0.03)	0.264*** (0.035)	0.264*** (0.036)	0.231*** (0.027)	0.234*** (0.028)	0.272*** (0.033)	0.270*** (0.032)
Large	0.439*** (0.035)	0.430*** (0.034)	0.535*** (0.045)	0.530*** (0.045)	0.469*** (0.031)	0.458*** (0.03)	0.577*** (0.037)	0.568*** (0.036)
Observations	40,640	40,569	41,185	41,171	42,151	42,081	42,742	42,722

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so we have endogeneity

**Table 13** The effect of GVC participation of firms having financial constraints (factual-based and perception-based) on innovation

	Extended probit <i>Factual-based</i>				Extended probit <i>Perception-based</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation
Two-way	0.818*** (0.149)				0.785*** (0.134)			
GVC certification		0.871*** (0.250)				0.857*** (0.196)		
GVC foreign			0.723*** (0.278)				0.726*** (0.162)	
GVC all				0.732** (0.322)				0.867*** (0.174)
FC	-1.252*** (0.114)	-1.296*** (0.109)	-1.305*** (0.121)	-1.311*** (0.121)	-1.049*** (0.148)	-1.059*** (0.152)	-1.080*** (0.137)	-1.101*** (0.130)
Two-way × FC	-0.239*** (0.092)				-0.161*** (0.036)			
GVC certification × FC		-0.287** (0.136)				-0.178*** (0.06)		
GVC foreign × FC			-0.301** (0.150)				-0.151** (0.064)	
GVC all × FC				-0.318 (0.213)				-0.345*** (0.071)
Capacity utilization	-0.002** (0.001)	-0.002** (0.001)	-0.002** (0.001)	-0.002** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)
Employment growth	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.002* (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)
Informal competent	0.172** (0.085)	0.169* (0.09)	0.158* (0.09)	0.154* (0.09)	0.252*** (0.07)	0.246*** (0.072)	0.236*** (0.07)	0.233*** (0.069)
Medium	0.143*** (0.019)	0.155*** (0.021)	0.181*** (0.024)	0.183*** (0.024)	0.157*** (0.018)	0.170*** (0.019)	0.194*** (0.022)	0.193*** (0.021)
Large	0.257*** (0.025)	0.265*** (0.027)	0.352*** (0.034)	0.353*** (0.034)	0.278*** (0.026)	0.291*** (0.028)	0.372*** (0.032)	0.369*** (0.032)
Observations	40,689	40,616	41,235	41,219	41,834	41,761	42,424	42,402

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so we have endogeneity



**Table 14** The effect of GVC participation and financial constraints (using the new definitions) on R&D expenditure

	Extended probit <i>Factual-based</i>				Extended probit <i>Perception-based</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
Two-way	0.950*** (0.205)				0.711*** (0.171)			
GVC certification		0.917*** (0.214)				0.742*** (0.149)		
GVC foreign			0.629** (0.253)				0.484*** (0.140)	
GVC all				0.645*** (0.229)				0.637*** (0.139)
FC Perception	-1.233*** (0.103)	-1.309*** (0.0854)	-1.304*** (0.0949)	-1.316*** (0.0928)	-1.229*** (0.042)	-1.257*** (0.031)	-1.280*** (0.030)	-1.292*** (0.033)
Two-way × FC	-0.154** (0.0648)				-0.172*** (0.034)			
GVC certification × FC		-0.291*** (0.0720)				-0.230*** (0.047)		
GVC foreign × FC			-0.211* (0.117)				-0.243*** (0.07)	
GVC all × FC				-0.359** (0.150)				-0.424*** (0.084)
Capacity utilization	-0.004*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)
Employment growth	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.0004 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Informal competent	0.117 (0.076)	0.113 (0.074)	0.01 (0.07)	0.095 (0.065)	0.206*** (0.059)	0.205*** (0.057)	0.194*** (0.052)	0.193*** (0.05)
Medium	0.245*** (0.034)	0.252*** (0.037)	0.299*** (0.041)	0.300*** (0.042)	0.229*** (0.028)	0.237*** (0.029)	0.271*** (0.034)	0.268*** (0.033)
Large	0.483*** (0.045)	0.476*** (0.045)	0.615*** (0.053)	0.610*** (0.052)	0.454*** (0.033)	0.453*** (0.03)	0.563*** (0.038)	0.552*** (0.036)
Observations	40,640	40,569	41,185	41,171	41,788	41,717	42,377	42,357

(i) Each column represents an individual regression. (ii) \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ . (iii) Robust standard errors in parentheses. Standard errors are clustered by country. (iv) All regressions include country, region, industry, and year fixed effects. (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so we have endogeneity

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**Availability of data and materials** The datasets analyzed during the current study are available in Enterprise Surveys, The World Bank, <http://www.enterprisesurveys.org>.

**Code availability** Stata is the software used.

## Declarations

**Conflict of interest** The authors declare no competing interests.

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## References

- Aghion, P., Askenazy, P., Berman, N., Cetto, G., & Eymard, L. (2012). Credit constraints and the cyclicity of R&D investment: Evidence from France. *Journal of the European Economic Association*, 10(5), 1001–1024. <https://doi.org/10.1111/j.1542-4774.2012.01093.x>
- Ali, N., Najaman, B. (2015). Informal competition and productivity in Sub-Saharan Africa. In: *Paper presented at the Annual Meeting of the French Economic Association*.
- Antras, P. (2019). Conceptual aspects of global value chains. *Harvard University*. <https://doi.org/10.1596/1813-9450-9114>
- Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In R. Nelson (Ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton University Press. <https://doi.org/10.1515/9781400879762-024>
- Ayalew, M. M., & Xianzhi, Z. (2019). The effect of financial constraints on innovation in developing countries: Evidence from 11 African countries. *Asian Review of Accounting*, 28(3), 273–308. <https://doi.org/10.1108/ara-02-2019-0036>
- Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: The role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, 46(6), 1545–1580. <https://doi.org/10.1017/s0022109011000378>
- Bernard, A., & Jensen, J. (2004). Why some firms export. *The Review of Economics and Statistics*, 86(2), 561–569. <https://doi.org/10.1162/003465304323031111>
- Boldrin, M., & Levine, D. K. (2008). Perfectly competitive innovation. *Journal of Monetary Economics*, 55(3), 435–453. <https://doi.org/10.1016/j.jmoneco.2008.01.008>
- Brancati, E., Brancati, R., & Maresca, A. (2017). Global value chains, innovation and performance: Firm-level evidence from the Great Recession. *Journal of Economic Geography*, 17(5), 1039–1073. <https://doi.org/10.1093/jeg/lbx003>
- Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, 64, 151–185. <https://doi.org/10.1111/j.1540-6261.2008.01431.x>
- Chundakkadan, R. & Sasidharan, S. (2019). Financial constraints, government support, and firm innovation: Empirical evidence from developing economies. *Innovation and Development*, 1–23. <https://doi.org/10.1080/2157930x.2019.1594680>
- Czarnitzki, D., & Hottenrott, H. (2011). R&D investment and financing constraints of small and medium-sized firms. *Small Business Economics*, 36(1), 65–83. <https://doi.org/10.1007/s11187-009-9189-3>
- Dang, A., & Dang, V. (2020). *Global value chain participation and firms' innovations: Evidence from small and medium-sized enterprises in Viet Nam*. Asian Development Bank.
- Dovis, M., & Zaki, C. (2020). Correction to: Global value chains and local business environments: Which factors really matter? *Review of Industrial Organization*. <https://doi.org/10.1007/s11151-020-09776-w>
- Engel, J., & Taglioni, D. (2017). The middle-income trap and upgrading along global value chains. *Chap. 5 in World Bank et al., Measuring and Analyzing the Impact of GVCs on Economic Development*. Washington, DC: World Bank. <https://doi.org/10.20561/00049249>
- Fernandez, V. (2017). The finance of innovation in Latin America. *International Review of Financial Analysis*, 53, 37–47. <https://doi.org/10.1016/j.irfa.2017.08.008>
- Fevolden, A., & Grønning, T. (2010). Combining innovation and capacity utilization in high throughput systems: Moving beyond the product life cycle model by introducing second-order innovations. *Industry and Innovation*, 17(6), 609–628. <https://doi.org/10.1080/13662716.2010.530840>
- Fort, T. C., Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2013). How firms respond to business cycles: The role of firm age and firm size. *IMF Economic Review*, 61(3), 520–559. <https://doi.org/10.1057/imfer.2013.15>
- Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, 48, 37–70. [https://doi.org/10.1016/s0022-1996\(98\)00075-0](https://doi.org/10.1016/s0022-1996(98)00075-0)
- Gereffi, G. (2005). The Global Economy: Organization, Governance, and Development. In Neil J. Smelser & Richard Swedberg (Eds.), *The Handbook of Economic Sociology* (2nd ed., pp. 160–82). Princeton University Press.
- Gereffi, G. (2014). Global value chains in a post-Washington Consensus world. *Review of International Political Economy*, 21(1), 9–37. <https://doi.org/10.1080/09692290.2012.756414>
- Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy*, 12(1), 78–104. <https://doi.org/10.1080/09692290500049805>
- Gereffi, G. (2019). Economic upgrading in global value chains. Chapters, in: Stefano Ponte & Gary Gereffi & Gale Raj-Reichert (Eds.), *Handbook on Global Value Chains*,

- chapter 14, pages 240–254. Edward Elgar Publishing. <https://doi.org/10.4337/9781788113779.00022>
- Giuliani, E., Pietrobelli, C., & Rabellotti, R. (2005). Upgrading in global value chains: Lessons from Latin American clusters. *World Development*, 33(4), 549–573. <https://doi.org/10.1016/j.worlddev.2005.01.002>
- Gómez-Ramírez, L. (2019). Credit constraints and investment in Mexico, an empirical test. *Revista Mexicana de Economía y Finanzas*, 14(3), 415–432. <https://doi.org/10.21919/remef.v14i3.311>
- Gorodnichenko, Y., & Schnitzer, M. (2013). Financial constraints and innovation: Why poor countries don't catch up. *Journal of the European Economic Association*. <https://doi.org/10.1111/jeea.12033>
- De Haas, R., Lu, L., & Ongena, S. (2018). Close competitors? On the causes and consequences of bilateral bank competition. *Discussion Paper 2018–027*, Tilburg University, Center for Economic Research. <https://doi.org/10.2139/ssrn.3276261>
- Henn, C., Papageorgiou, C., Romero, J. M., & Spatafora, N. (2020). Export quality in advanced and developing economies: Evidence from a new data set. *IMF Economic Review*. <https://doi.org/10.1057/s41308-020-00110-8>
- Hewitt-Dundas, N. (2006). Resource and capability constraints to innovation in small and large plants. *Small Business Economics*, 26(3), 257–277. <https://doi.org/10.1007/s11187-005-2140-3>
- Holmstrom, B. (1989). Agency costs and innovation. *Journal of Economic Behavior & Organization*, 12(3). [https://doi.org/10.1016/0167-2681\(89\)90025-5](https://doi.org/10.1016/0167-2681(89)90025-5)
- Huang, Y. (2016). Can China escape the middle-income trap? *China Economic Journal*, 9(1), 17–33. <https://doi.org/10.1080/17538963.2015.1122882>
- Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies*, 36(9), 1017–1027. <https://doi.org/10.1080/0034340022000022198>
- IMF. (2016). *Global financial stability report: Fostering stability in a low-growth, low-rate era*. IMF.
- Jones, L., Demirkaya, M., & Bethmann, E. (2019). Global value chain analysis: Concepts and approaches. *Journal of International Commerce and Economics*, 1, 1–29.
- Kerr, W. R., & Nanda, R. (2015). Financing innovation. *Annual Review of Financial Economics*, 7, 445–462. <https://doi.org/10.1146/annurev-financial-111914-041825>
- Kuntchev, V., Ramalho, R., Rodríguez-Meza, J., & Yang, J. S. (2013). *What have we learned from the enterprise surveys regarding access to credit by SMEs?* World Bank. <https://doi.org/10.1596/1813-9450-6670>
- Lööf, H., & Heshmati, A. (2006). On the relationship between innovation and performance: A sensitivity analysis. *Economics of Innovation and New Technology*, 15(4–5), 317–344. <https://doi.org/10.1080/10438590500512810>
- De Marchi, V., Giuliani, E., & Rabellotti, R. (2015). Local innovation and global value chains in developing countries. *MERIT Working Papers 2015–022*, United Nations University – MERIT.
- Mohnen, P., & Röller, L. H. (2005). Complementarities in innovation policy. *European Economic Review*, 49(6), 1431–1450. <https://doi.org/10.1016/j.euroecorev.2003.12.003>
- Montalbano, P., Nenci, S., & Pietrobelli, C. (2018). Opening and linking up: Firms, GVCs, and productivity in Latin America. *Small Business Economics*, 50(4), 917–935. <https://doi.org/10.1007/s11187-017-9902-6>
- Mortensen, P. S., & Bloch, C. W. (2005). *Oslo manual-guidelines for collecting and interpreting innovation data: Proposed guidelines for collecting and interpreting innovation data*. OECD.
- OECD (2013). *Interconnected economies: Benefiting from global value chains*. OECD Publishing. <https://doi.org/10.1787/9789264189560-en>
- Okumu, I. M., Bbaale, E., & Guloba, M. M. (2019). Innovation and employment growth: Evidence from manufacturing firms in Africa. *Journal of Innovation and Entrepreneurship*, 8, 7. <https://doi.org/10.1186/s13731-019-0102-2>
- Oudgou, M. (2021). Financial and non-financial obstacles to innovation: Empirical evidence at the firm level in the MENA region. *Journal of Open Innovation Technology, Market and Complexity*. <https://doi.org/10.3390/joitmc7010028>
- Pietrobelli, C., & Rabellotti, R. (2011). Global value chains meet innovation systems: Are there learning opportunities for developing countries? *World Development*, 39(7). <https://doi.org/10.1016/j.worlddev.2010.05.013>
- Reddy, K., Chundakkadan, R., & Sasidharan, S. (2021). Firm innovation and global value chain participation. *Small Business Economics*. <https://doi.org/10.1007/s11187-020-00391-3>
- Reddy, K. (2020). Financial constraints and global value chains participation of Indian MSMEs. *The Indian Economic Journal*, 68(1), 118–121. <https://doi.org/10.1177/0019466220946325>
- Savnigac, F. (2008). Impact of financial constraints on innovation: What can be learned from a direct measure? *Economics of Innovation and New Technology*, 17(6), 553–569. <https://doi.org/10.1080/10438590701538432>
- Scopelliti, I., Cillo, P., Busacca, B., & Mazursky, D. (2014). How do financial constraints affect creativity? *Journal of Product Innovation Management*, 31(5), 880–893. <https://doi.org/10.1111/jpim.12129>
- StataCorp. (2021). *STATA extended regression models reference manual: Release 17*. Stata Press.
- Tajoli, L., & Felice, G. (2018). Global value chains participation and knowledge spillovers in developed and developing countries: An empirical investigation. *The European Journal of Development Research*, 30(3), 505–532. <https://doi.org/10.1057/s41287-017-0127-y>
- UNCTAD (2015). *Tracing the value added in global value chains: Product-level case studies in China*
- UNESCAP (2015). *Global value chains, technology transfers and innovation. Asia-Pacific Trade and Investment Report 2015*. <https://doi.org/10.18356/738906b9-en>
- Van Biesebroeck, J. (2014). *Productivity, exporting and financial constraints of Chinese SMEs*. Inter-American Development Bank.
- WBES (2021). *Enterprise Surveys*, The World Bank, available at: <http://www.enterprisesurveys.org>. Accessed 15 Feb 2021
- World Bank (2019). *World Development Report 2020: Trading for Development in the Age of Global Value Chains*. <https://doi.org/10.1596/978-1-4648-1457-0>

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